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The new technology discussed here will enable wireless monitoring and communication with a wide variety of mobile and stationary energy storage systems, including primary and secondary batteries, such as lithium-ion batteries, capacitors, fuel cells, engines, hybrids, converters, photovoltaic cells, thermoelectric generators, gas and steam turbines, sterling engines, electrical generators and motors, fuel tanks and sub-stations. Given the safety challenges facing lithium-ion batteries in EV applications, such sensors may be particularly important to the emerging EV market. These wireless suites of sensors and readers eliminate the need for massive wiring harnesses necessary to carry sensor signals, and allows for the painless incorporation of large arrays of sensors for the control of hybrid energy systems, as well as enhanced performance, safety, and reliability. This increases operating efficiency, prolongs life of system, and increases reliability. The proposed work leverages advancements made from an earlier ARPA-e funded project that developed prototype sensors for wireless battery management systems for lithium-ion battery packs. The accomplishments that will be reported include: (1) flexible wireless tags and sensors, using Bluetooth 4.0 standard; (2) small receivers compatible with USB ports on portable computers; (3) software drivers and logging software; (4) flexible wireless controllers, also using Bluetooth 4.0 standard, essential for balancing large-scale battery packs; (4) demonstrations performed to date, with examples of the data acquired.

The 2.5 kWh Li-Ion battery pack for NASA's Mars Science Laboratory developed by Yardney Technical Products requires massive wiring harness; more sensors are needed in such systems without the proliferation of massive wiring harness. Elimination of the wiring harness will increase reliability, decrease weight, and increase mass-specific power and energy. The proposed wireless sensors and controllers provide a means of eliminating the massive wiring harnesses, and are capable of increasing safety, reliability, specific power, and specific energy. Prototypical passive wireless sensors are capable of simultaneously monitoring several voltages, current, strain and temperature, ideally suited for monitoring energy conversion and storage devices, including but not limited to photovoltaic cells, thermoelectric generators, primary and secondary electrochemical batteries, capacitors, flywheels, and various types of generators.

Wireless voltage sensors, being operated in a passive mode, are capable of following terminal voltage of individual lithium-ion cells in battery pack during charge-discharge cycling. Similarly, wireless temperature sensors are capable of following the temperatures of individual lithium-ion cells in high-capacity battery pack during charge-discharge cycling. The same capability can be used for monitoring localized temperatures from a large array of distributed thermistors. Wireless strain gauges are capable of following the swelling of individual lithium-ion cells in battery pack, as shown in Figure 6. The same capability can be used for monitoring localized strain in individual cells, from a large array of distributed strain gauges, as indicators of internal pressure in the cells.

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